

IMAGE PROCESSING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to an image
processing apparatus, an automatic focus detecting
apparatus, a correction apparatus, a correction method,
respectively capable of obtaining a highly precise
signal, and to a storage medium storing a program
10 realizing the functions of the apparatuses and method.

Related Background Art

Following conventional noise eliminating methods
are known.

15 In an automatic focus detector of a camera or the
like, a light beam becomes incident upon a distance
measurement optical system and is focussed upon a
photoelectric conversion unit with a plurality of line
sensors. An output of the photoelectric conversion
unit is supplied to a distance measurement unit
20 (generally a microprocessor with a built-in
input/output control program for the photoelectric
conversion unit and a built-in focus detecting and
calculating program) to obtain the focal point.

25 Noise correction methods for a photoelectric
conversion unit usable with an automatic focus detector
are described, for example, in Japanese Patent
Application Laid-Open Nos. 9-26540 and 10-190038.

According to Japanese Patent Application Laid-Open No. 9-26540, a dark current detector is provided for shading a partial area of each of CCD line sensors picking up different portions of an image of a subject to measure an amount of a dark current. The dark current of each line sensor is corrected in accordance with the light amount integration time (accumulation time). According to Japanese Patent Application Laid-Open No. 10-190038, a plurality of load MOS transistors is provided for each output line, the load MOS transistor determining the gain of electric charges of each pixel of an area sensor which charges are inversely amplified and stored. One of the load MOS transistors is selected which, together with a sensor amplifier MOS transistor, makes the fixed pattern noises smallest. In this manner, by devising hardware, the fixed pattern noises are reduced.

Noise elimination for a photoelectric conversion unit usable for picking up an image of a subject is disclosed in Japanese Patent Application Laid-Open No. 6-253217. During the operation of a photoelectric conversion unit, the state while a light beam is not incident and the state while a light beam is incident are alternately repeated. According to Japanese Patent Application Laid-Open No. 6-253217, during the state while a light beam is not incident upon the photoelectric conversion unit, an output of the unit is

stored which is subtracted from an output while a light beam is incident. In this manner, dark current components are eliminated.

5 A dark current is an error signal proportional to the accumulation time and independent from an amount of incidence light upon a photoelectric conversion unit. Fixed pattern noises are noises specific to each pixel of a photoelectric conversion unit and independent from an incidence light amount and accumulation time. Fig. 10 1 is a schematic diagram showing how dark current and fixed pattern noises change with each pixel of a photoelectric conversion unit and an accumulation time.

15 Pixels 1 to n shown in Fig. 1 are the pixels of a photoelectric conversion unit. The abscissa represents an accumulation time, and the ordinate represents an error signal of the photoelectric conversion unit. The fixed pattern noise is constant irrespective of whether the accumulation time is long or short. The amplitude of the fixed pattern noise changes with each pixel. 20 The dark current increases as the accumulation time becomes long. The amplitude of the dark current which increases in proportion to the accumulation time changes with each pixel. If the accumulation time is near 0, the dark current of each pixel becomes 25 negligibly small.

Fig. 2 shows a relationship between levels of fixed pattern noises of respective pixels of the

photoelectric conversion unit and a threshold level
FPNs used as a criterion for judging a defect chip. If
the fixed pattern noises are larger than FPNs, the
error signal affects the image processing to be
5 executed after the light exposure, and there is a
possibility that an image taken with a camera under an
AF operation becomes out of focus. A conventional
focus detector selectively uses a photoelectric
conversion unit having fixed pattern noises smaller
10 than FPNs. Since a variation range of fixed pattern
noises of pixels is small, it is sufficient for fixed
pattern noise correction that each pixel train with a
plurality of pixels of a photoelectric conversion unit
is corrected by using the same correction value. For
15 example, it is possible to presume that the fixed
pattern noises of pixels shown in Fig. 1 are the same.
Therefore, only the dark current is corrected by using
different correction values for respective pixels.

Another example of a photoelectric conversion unit
20 usable for taking an image of a subject is shown in
Fig. 3. First, the circuit structure of the
photoelectric conversion unit will be described. In
Fig. 3, reference numeral 51 represents a pixel,
reference numeral 52 represents a vertical scanning
25 circuit, reference numeral 53 represents a capacitor
for storing a signal combined with an optical signal
and a noise signal of each pixel, reference numeral 54

represents a capacitor for storing a noise signal of each pixel, reference numerals 55 and 56 represent transfer MOS transistors for transferring a signal of each pixel to the capacitors 53 and 54, reference
5 numerals 57 and 58 represent transfer MOS transistors for transferring signals stored in the capacitors 53 and 54 to horizontal output lines 59 and 60, reference numeral 61 represents a horizontal scanning circuit, and reference numeral 62 represents a differential
10 amplifier for amplifying a difference between two signals.

Next, the operation of the photoelectric conversion unit will be described. First, pixels are reset and a noise signal (N) after resetting is
15 transferred to the capacitor 54. Next, the light exposure is performed so that the pixel has a signal combined with an optical signal (S) and a noise signal (N). This signal is transferred to the capacitor 57. The capacitor 57 stores signals $S + N$ and the capacitor
20 58 stores the signal N. These signals are read to the horizontal output lines 59 and 60. Lastly, the differential amplifier circuit 62 outputs only the light signal $S ((S+N)-N)$.

Such a noise elimination method is also applied to
25 a photoelectric conversion unit with pixels arranged in one-dimension.

Although noises can be eliminated by the above-

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SUMMARY OF THE INVENTION

In order to achieve the above object, according to one aspect of the present invention, there is provided an image processing apparatus comprising: a photoelectric conversion unit including a pixel; and noise correction means for correcting noises in a signal output from the pixel in accordance with noise information obtained from the pixel during two or more arbitrary different accumulation times.

According to another aspect of the present invention, there is provided an automatic focus

detecting apparatus comprising: a photoelectric conversion unit including a plurality of pixels; noise correction means for correcting noises in a signal output from the pixel in accordance with noise information of the pixel obtained during two or more arbitrary different accumulation times; and distance measurement calculation means for performing a distance measurement calculation in accordance with a signal corrected by the noise correction means.

10 According to another aspect of the present invention, there is provided an automatic focus detecting apparatus comprising: a photoelectric conversion unit including a plurality of pixels; storage means for storing noise information of a pixel independent from an accumulation time and noise information of a pixel dependent upon the accumulation time; noise correction means for correcting noises in a signal output from the photoelectric conversion unit in accordance with the respective noise information stored in the storage means; and distance measurement calculation means for performing a distance measurement calculation in accordance with a signal corrected by the noise correction means.

25 According to another aspect of the present invention, there is provided a correction apparatus comprising: noise correction means for correcting noises from a signal output from a pixel in a

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photoelectric conversion unit, in accordance with noise information of the pixel obtained during two or more arbitrary different accumulation times.

According to another aspect of the present invention, there is provided a correction method comprising the step of correcting noises from a signal output from a pixel in a photoelectric conversion unit, in accordance with noise information of the pixel obtained during two or more arbitrary different accumulation times.

According to another aspect of the present invention, there is provided a storage medium storing a program comprising the step of correcting noises from a signal output from a pixel in a photoelectric conversion unit, in accordance with noise information of the pixel obtained during two or more arbitrary different accumulation times.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram showing a relation between fixed pattern noises, dark currents and accumulation time of pixels according to conventional techniques.

Fig. 2 is a graph showing an example of a variation in noise levels of a conventional photoelectric conversion unit.

Fig. 3 is a circuit diagram of a photoelectric

conversion unit with a conventional noise eliminating function.

Fig. 4 is a schematic diagram showing a relation between fixed pattern noises, dark currents and accumulation time of pixels, according to an embodiment of the invention.

Fig. 5 is a graph showing an example of a variation in noise levels of a photoelectric conversion unit.

Figs. 6A, 6B and 6C are diagrams showing distance measurement areas and pixel layout of a sensor using an area AF.

Figs. 7A, 7B and 7C are diagrams showing distance measurement areas and pixel layout of a sensor using a conventional multi-point (three points) AF.

Fig. 8 is a circuit block diagram of a single-lens reflex camera.

Fig. 9 is a flow chart illustrating an accumulation start process of the photoelectric conversion unit.

Fig. 10 is a flow chart illustrating a sleep loop for waiting for an accumulation completion while an output of the photoelectric conversion unit is A/D converted.

Fig. 11 is a flow chart illustrating an operation of an accumulation completion interruption handler activated upon an accumulation completion.

Fig. 12 is a flow chart illustrating an operation of determining a fixed pattern noise correction value.

Fig. 13 is a flow chart illustrating an operation of determining a dark current correction value.

5 Fig. 14 is a flow chart illustrating a whole operation sequence of the camera.

Fig. 15 is a flow chart illustrating an AF control sub-routine.

10 Fig. 16 is a flow chart illustrating a focus detection sub-routine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Area AF such as illustrated in Figs. 6A to 6C is prevailing in order to broaden a focus area on an image pickup screen of an autofocussing camera. A
15 conventional photoelectric conversion unit 70 shown in Figs. 7A to 7C uses a plurality of line sensors 31 with pixels disposed linearly. A photoelectric conversion unit 30 shown in Figs. 6A to 6C using area AF uses area
20 sensors 31 with dense pixel trains disposed in each area, so that a broad area on an image pickup area can be focussed. In this embodiment, the photoelectric conversion unit uses area sensors having a plurality of inversion amplification type pixels disposed in each
25 area as disclosed in Japanese Patent Application Laid-Open No. 10-190038. This area sensor 31 has a number of pixels on one chip larger than that of a

conventional line sensor. Therefore, a variation in levels of fixed pattern noises of pixels is likely to become large, because of various restrictions on the manufacture processes of a photoelectric conversion chip. As seen from a comparison between Figs. 2 and 5, the variation of fixed pattern noises becomes larger than that of a conventional photoelectric conversion unit, for the following reasons.

With reference to Figs. 6A to 6C and Figs. 7A to 7C, the area AF sensor of this embodiment is compared to a conventional three-point AF sensor. The area AF uses a number of distance measurement areas such as shown in Fig. 6A, whereas the three-point AF has three distance measurement areas such as shown in Fig. 7A. Figs. 6B and 7C show the layout of area sensors 31 and line sensors 71 and the layout of pixels. In Fig. 6B, pixels are disposed in a matrix pattern, whereas in Fig. 7B, pixels are disposed linearly. Fig. 7C shows the layout of distance measurement pixel trains. Fig. 6C shows a number of distance measurement pixel trains including n distance measurement pixel trains A1 to An corresponding to n distance measurement pixel trains B1 to Bn. In Fig. 7C, three distance measurement areas are formed including the center area and opposite side areas, the center area being constituted of four pixel trains a2, b2, c1 and d1, the side area being constituted of two pixel trains a1 and b1, and the

other side area being constituted of two pixel trains
a3 and b3.

When a subject image is focussed by a distance
measurement optical system on the sensor, each pixel
5 generates, through photoelectric conversion, electric
charges corresponding in amount to the incident light
amount. In this case, if the accumulation time (a time
taken to complete photoelectric conversion after the
sensor is reset) is set to the same value for all
10 distance measurement pixel trains, and if the
brightness of the subject image differs greatly at
respective distance measurement areas, then the light
amount during the accumulation time may become
insufficient and the charge amount may become
15 insufficient, or the light amount may become excessive
and the charge may overflow from the memory. From this
reason, the accumulation time is generally determined
differently for each distance measurement pixel train.
For example, in the sensor shown in Fig. 7A, if a white
20 wall of a house in the sun is in the right distance
measurement area and a black iron bar in the shade of a
tree is in the left distance measurement area, the
brightness in the right distance measurement area is
greatly different from that in the left distance
25 measurement area. In this case, therefore, an
accumulation control circuit of the sensor controls to
set the accumulation time for the pixel trains a3 and

b3 in the right distance measurement area shorter and the accumulation time for the pixel trains a1 and b1 in the left distance measurement area longer. The accumulation control circuit monitors a difference
5 between the maximum and minimum potentials of pixels in each pixel train, and when the difference exceeds a predetermined value, the accumulation control circuit issues an accumulation completion signal. Alternatively, if a longest accumulation time comes,
10 the accumulation is stopped.

An accumulation time can be measured from a difference between the time when an accumulation start signal is issued to the AF sensor and the time when the accumulation completion signal is issued, by using the
15 timer function of a microprocessor usually connected to the AF sensor.

In a conventional photoelectric conversion unit, an accumulation completion signal is output to each distance measurement area. Namely, in the sensor shown
20 in Fig. 7C, an accumulation control circuit is provided for each of a pair (line sensor pair) of pixel trains a1 and b1, a pair of a2 and b2, a pair of a3 and b3 and a pair of c1 and d1. Four accumulation completion signal lines are connected from the four line sensor
25 pairs to input ports of the microprocessor. The microprocessor can know from the accumulation completion signal arrived at a certain input port that

the accumulation is completed at the pixel trains in the corresponding distance measurement area.

In the photoelectric conversion unit using the area AF, the number of accumulation completion signal lines extending from the accumulation control circuits of the distance measurement areas to the external increases as the number of distance measurement areas becomes large. With the conventional notification measure of accumulation completion, it is necessary to prepare accumulation control circuits and signal lines as many as the number proportional to the number of distance measurement areas. Since there are several tens or more of the distance measurement areas, the number of ports of the microprocessor and the mount area of lines between the sensor and microcomputer are not suitable for a focus detector used with a compact camera. In view of this, in the embodiment area AF, the accumulation control circuit scans all the pixel trains at high speed. If there is a pixel train whose accumulation was completed, the accumulation control circuit stores the pixel train number and issues an accumulation completion signal to the microcomputer which in turn inquires the accumulation completion pixel train number to the area sensor. In response this, the accumulation control circuit returns the information on the accumulation completion pixel train in the distance measurement area. Only one

accumulation control circuit is therefore sufficient and only one accumulation completion signal line is used. However, since it is necessary to scan a large number of pixel trains, the control circuit disposed
5 adjacent to pixels is driven at high speed and may become a noise source.

Conventionally, pixel trains are not dense so that a fixed pattern noise eliminator circuit is mounted in a relatively large area with a sufficient area margin.
10 In the area sensor using the area AF, an area of pixels occupies most of the area sensor area. Therefore, if other circuits are to be disposed occupying an area like a conventional line sensor, the size of the circuit becomes too large and the circuit is difficult
15 to be mounted on a camera desired to be made compact. In order to solve this problem, the circuit is made finer and the circuit component is made more compact. As a result, the sensor manufacture allowance greatly influences the variation in levels of fixed pattern
20 noises of pixels. If mass produced good sensors are selected which enter the allowable variation range of levels of fixed pattern noises of pixels same as the conventional range, the manufacture yield becomes very poor and the production cost becomes high because the
25 variation in levels of fixed pattern noises in an area sensor is essentially larger than that of a line sensor. The cost of the focus detector unit therefore

becomes high, and the cost of the camera using this focus detector unit also becomes high.

If the allowable variation range is broadened and sensors having large fixed pattern noises are used as good sensors in order to raise the manufacture yield, the following problems occur. Since such area sensors have a large output error, the reliability of distance measurement of a focus detector unit lowers and the performance of the focus detector unit is degraded.

These problems may be solved by incorporating a circuit structure which prevents noise interference. However, there is a trade-off between the suppression of fixed pattern noises by hardware and the compactness of the sensor. In making the sensor compact, there arise the problem of a smaller capacitance of the capacitor because of a reduced area of a photoelectric conversion pixel memory circuit with high integration, the problem of a layout of an accumulation control circuit and a memory circuit disposed near to each other, and other problems.

It is to be noted that the fixed pattern noises are constant for each pixel in terms of reproductivity.

In this embodiment, therefore, in order to solve the above problems, outputs of an area sensor of a photoelectric conversion unit, including a variation in fixed pattern noises, are corrected by using software on a microprocessor which functions as a computation

unit. The fixed pattern noises have a constant output level for each pixel. Therefore, when the microprocessor reads a pixel output of the area sensor, the microprocessor corrects this pixel output by using
5 a fixed pattern noise output level of the pixel stored in advance in a memory, and uses the corrected pixel output for distance measurement. Therefore, even an area sensor having a larger variation in fixed pattern noise levels than a line sensor can be used as a good
10 sensor without judging it as a defect sensor. The manufacture yield can thus be prevented from being lowered.

Correcting the fixed pattern noises is generally associated with correcting the dark current. However,
15 the level of the fixed pattern noises is very different from the variation in the dark current. Therefore, correcting at the same time both the fixed pattern noises and dark current is not preferable in terms of correction precision and correction range.

20 In this embodiment, therefore, correcting the dark noise of each pixel is performed independently from correcting the fixed pattern noises.

For such the correction, correction data is stored in advance in a non-volatile memory by performing the
25 following processes.

1) A pixel output is read in the state that light is not incident upon a photoelectric conversion unit,

to measure fixed pattern noise components of each pixel.

2) A relation between an accumulation time and a pixel output is measured in the state that light is not incident upon the photoelectric conversion unit, and the dark current components of each pixel is calculated from the pixel output subtracted by the fixed pattern noise components, by referring to the relation between the accumulation time and pixel output.

The above processes are executed for each pixel to generate fixed pattern noise correction information and dark current correction information specific to each pixel, and the correction information is stored in a memory of a controller unit combined with the photoelectric conversion unit.

In order to utilize a pixel output of the photoelectric conversion unit, the focus detector unit processes this pixel output by referring to a correspondence between the pixel and accumulation time. The fixed pattern noise components are first obtained from the correction information and subtracted from the pixel output. Then, by referring to the relation between the accumulation time and dark current, the dark current components are obtained and subtracted from the pixel output. With these processes, a precision of the output data of the photoelectric conversion unit can be improved.

Embodiments of the invention will be described in detail.

First, the focus detector unit used by the embodiments will be described.

5 Fig. 8 is a block diagram showing the circuit structure of a single-lens reflex camera having an automatic focus detector unit.

Referring to Fig. 8, PRS is a control circuit of the camera, and, for example, a one-chip microcomputer having a CPU 32a (central processing unit), a ROM 32b, a RAM 32c, an EEPROM 32d, an A/D converter 32e and a timer TM 32f. This control circuit PRS performs a series of camera operations such as automatic exposure control, automatic focussing, and film feeding and taking-up, in accordance with a camera sequence program stored in ROM. To this end, the control circuit PRS communicates with peripheral circuits in the camera and controllers in a lens system, by using communication signals SO, SI, SCLK and communication select signals CLCM, CSDR and CDDR, to control the peripheral circuits and a motion of lenses, and to acknowledge an A/D conversion input and an interruption input and receive pixel data. ROM can store control data for peripheral circuits as well as the sequence program. A flash memory is used as ROM in which data specific to respective circuits is stored to perform the operations in accordance with this data.

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SO is a data signal output from the control circuit PRS to the photoelectric conversion unit SNS, SI is a data signal output from SNS to PRS, and SCLK is a synchronous signal for SO and SI.

5 A sensor drive circuit of the photoelectric conversion unit SNS for focus detection which unit being constituted of an area sensor 31, its control circuit and an external interface, is selected when the signal CSDR takes "H" and controlled by the control
10 circuit PRS by using SO, SI and SCLK. A photoelectrically converted analog signal is supplied to an A/D conversion port of PRS via a VIDEO line. An interruption signal for accumulation completion is supplied to an interruption input port of PRS via a
15 /TINTE line. An accumulation completion of the photoelectric conversion unit SNS of this embodiment occurs under the following conditions.

 Pixels are disposed in area sensors SNS-1a to SNS-2b such as area AF shown in Fig. 6B. In this case, if
20 distance measurement areas of the area AF are disposed in a layout such as shown in Fig. 6A, a layout of corresponding distance measurement pixel trains of a phase difference distance measurement type becomes as shown in Fig. 6C.

25 A subject image taken with a camera is projected via a distance measurement optical system upon an area sensor. Therefore, a difference of brightness on the

Next, the automatic focussing of this camera
constructed as above will be described with reference
to flow charts.

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AF control is executed starting from Step (010) to

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5 viewpoint of a photographer can be detected by an
unrepresented viewpoint input unit, the distance
measurement area can be selected in accordance with the
viewpoint of the photographer. The details of the
viewpoint input are not given in this embodiment.

Next, at Step (113) a sub-routine "accumulation start" is executed. This sub-routine starts the

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accumulation operation of the area sensor. More specifically, an accumulation start command is issued to the sensor SNS to start the accumulation operation, and at the same time, and the sensor SNS is set so that
5 the control circuit PRS can recognize "accumulation completion" by the sensor accumulation completion signal /TINTE supplied from the sensor SNS.

The sub-routine "accumulation start" will be described.

10 Fig. 9 is a flow chart illustrating the sub-routine "accumulation start". When the sub-routine "accumulation start" is activated starting from Step (800), area sensor communication is initialized at Step (801). Namely, the communication state with the
15 photoelectric conversion unit SNS is initialized. With this initialization, the control circuit PRS can transmit control signals to the photoelectric conversion unit SNS and receive the photoelectric conversion results supplied from the photoelectric
20 conversion unit SNS.

At Step (802) the conditions of photoelectric conversion unit SNS are initialized. At this Step, the photoelectric conversion unit SNS is reset, the gain and a photoelectric conversion result read mode are
25 set, and other necessary operations are performed. The details of the initialization conditions and communication protocol for such setting are omitted in

this embodiment.

At Step (803) the accumulation timer TM is initialized. Namely, a built-in timer of the control circuit PRS is initialized so that the built-in timer
5 can be used properly as the accumulation time counting timer.

At Step (804) an accumulation completion interruption is set. With this accumulation completion interruption setting, the photoelectric conversion unit
10 SNS can interrupt the control circuit PRS by using the accumulation completion signal /TINTE generated upon detection of the accumulation completion of a pixel train in each distance measurement area constituted of several tens pixels of the area sensor. In order for
15 the control circuit PRS to respond to the interruption signal, an interruption permission, a priority order of accumulation completion interruptions and the like are set at this Step (804).

At Step (805), the accumulation timer starts
20 counting. The timer initialized at Step (803) is activated to start counting. At Step (806) the area sensor starts accumulation. At this Step, the control circuit PRS is set so that it can acknowledge an accumulation completion interruption issued immediately
25 after an accumulation start signal is sent to the area sensor. With this setting, the control circuit PRS can start the accumulation completion interruption process

immediately when the area sensor SNS informs the accumulation completion.

After Step (806), the control circuit enters a sleep state at Step (807). The sleep state means a temporary suspension of the operation of the control circuit PRS until the sleep release conditions are met. The sleep release conditions are met when a sleep release signal is issued by the accumulation completion interruption process. When the sleep state at Step (807) is released, the process resumes from Step next to the accumulation completion wait sleep Step (900). The sleep state is also released by a time-out error of an unrepresented time-out timer which error occurs when an accumulation completion takes an abnormally long time. This sleep state is also released by an abnormal operation such as the power-off during the operation and an insufficient battery capacity. However, the details of these are omitted because these are not relevant to the processes of the embodiment.

When the photoelectric conversion unit SNS which started accumulation becomes able to output the photoelectric conversion result, the photoelectric conversion unit SNS requests an interruption to the control circuit PRS by using the accumulation completion signal /TINTE. This is realized by setting the accumulation completion signal to "H". In response to this, the control circuit PRS calls the accumulation

When the accumulation completion interruption

5 process is activated by the accumulation completion
signal, the process starts from Step (1000). At Step
(1001) the time when the accumulation completion signal
is issued is obtained from the accumulation time
counting timer TM and accumulation time is obtained
10 from a difference between the time when the
accumulation completion signal is issued and the
accumulation timer counting start time stored at Step
(805).

At Step (1002) the accumulation completion pixel
train number is acquired from the photoelectric
conversion unit SNS through communications and stored
in RAM. If accumulation completion occurs at the same
time at a plurality of pixel trains, a plurality of
accumulation completion pixel train numbers are
transmitted.

At Step (1003) the analog signal value of the sensor output VIDEO is read from an area sensor input port (1008). If a plurality of accumulation completion pixel train numbers were received at Step (1002), the photoelectric conversion results are received from the photoelectric conversion unit SNS a plurality of times corresponding to the number of the received numbers and

A/D converted. In order to make the area sensor output the analog value of the photoelectric conversion result of each pixel train, a photoelectric conversion result request and accumulation completion pixel train number are supplied to the photoelectric conversion unit SNS which in turn outputs the photoelectric conversion result via the VIDEO line.

At Step (1004) the pixel train number, pixel number, photoelectric conversion result A/D value obtained at Step (1003), and accumulation time are stored in an A/D result buffer (1009).

At Step (1005) a sleeve release signal is sent to activate the process entered the sleep state at Step (807). However, until the interruption process is completed, the interruption process continues preferentially. Therefore, Step (1006) is continuously executed. At Step (1006) the accumulation completion interruption is set again for the preparation of the next accumulation completion interruption to be issued from the sensor SNS. The accumulation completion interruption is terminated at Step (1007).

At this time, the accumulation completion wait sleep at Step (900) shown in Fig. 10 is released upon reception of the sleep release signal, and the flow advances to Step (901). At Step (901), the A/D conversion result is read from the A/D result buffer (1009). The A/D result buffer stores the pixel train

number, A/D conversion value and accumulation time at Step (1004). In accordance with this information, the following processes are executed. This loop starts from Step (902). This loop is repeated the same times as the number of accumulation completion pixel trains newly stored in the A/D result buffer to process data of all the accumulation completion pixels obtained during the accumulation completion wait sleep.

At Step (903), the A/D conversion result corresponding to one of the accumulation completion pixel train numbers still not processed is read from the A/D result buffer.

At Step (904) the fixed pattern noise correction information and dark current correction information of each pixel of the pixel train is read from a fixed pattern noise correction information and dark current correction information database (912).

At Step (905) the A/D conversion results of the pixel train number and pixel number now under processing are corrected in accordance with the fixed pattern noise correction information. The corrected value AD2 is given by the following equation (1):

$$AD2 [i, j] = AD [i, j] - FPN [i, j] \quad \dots (1)$$

where AD is the A/D conversion result, FPN is the fixed pattern noise correction information, i is the pixel train number now under processing, and j is the pixel number of a pixel in the pixel train.

Next, at Step (906) the accumulation time is read from the A/D result buffer, and in accordance with this accumulation time the dark current correction is performed at Step (907). The corrected value AD3 is
5 given by the following equation (2):

$$AD3 [i, j] = AD2 [i, j] - DK [i, j] \times TM [i] \dots (2)$$

where DK is the dark current correction information and TM is the accumulation time. j is incremented by 1 by
10 an unrepresented loop, from 1 to the number m of pixels contained in the pixel train. The corrected values AD3 of all pixels in the pixel train are stored in the memory. The loop is terminated at Step (908) after all the new accumulation completion pixel trains are
15 corrected by repeating the above processes.

After the loop is terminated, the flow advances to Step (909) whereat it is checked whether the A/D conversion results of all the pixel trains of the sensor have been corrected completely. If not, the
20 flow returns to Step (900) to enter again the accumulation completion wait sleep, whereas if corrected completely, the flow advances to Step (910) to complete and terminate the photoelectric conversion A/D process.

25 The processes described above will be summarized.

An image projected upon the area sensor has a bright area and a dark area. Therefore, even if an

5 completion pixel trains identified by the accumulation
completion pixel train numbers are sequentially read
from the A/D conversion buffer to correct the fixed
pattern noise and dark current. This process is
repeated until the accumulation of all the pixel trains
0 is completed.

The correction given by the equation (1) corresponds to the fixed pattern noise correction of this invention, and the correction given by the equation (2) corresponds to the dark current correction. The dark current correction is corrected by the correction amount proportional to the accumulation time.

The processes at Step (113) are completed as above, and then at Step (114) the focus detection process returns to the main routine.

Although Steps (900 to 910) shown in Fig. 10 are executed by PRS provided in the same apparatus as the photoelectric conversion unit SNS, these Steps shown in Fig. 10 may be executed by a discrete PRS separate from the photoelectric conversion SNS and connectable thereto when necessary.

A program realizing the processes at Steps (900 to

910) may be stored in a storage medium such as a CD-ROM and a semiconductor memory, and data may be processed by an apparatus including the photoelectric conversion unit SNS, a CPU and a ROM storing the fixed pattern noise correction information and dark current noise correction information, by inserting the storage medium into this apparatus. If a program capable of processing at high speed is developed at a later time, this program can be easily written in such a storage medium.

Thereafter, the photographing operation continues. The detailed description thereof is omitted.

Next, a method of determining the fixed pattern noise correction value and dark current correction value to be stored in ROM will be described.

Fig. 12 is a flow chart illustrating a method of determining a fixed pattern noise correction value. This method may be performed by the control circuit PRS, or the fixed pattern noise correction value may be determined by preparing a program different from the focus detection process and another control circuit.

In order not to duplicate the already described processes such as the A/D conversion control for receiving the photoelectric conversion result from the sensor SNS, the processes after the data before correction of the photoelectric conversion unit SNS is stored in the A/D result buffer (1009) will be

described.

Prior to the setting of the accumulation completion interruption and a call of this sub-routine, the luminance of the light reception surface of the photoelectric conversion unit SNS is made uniform in order to measure the fixed pattern noise. For example, the light reception surface of the photoelectric conversion unit SNS is completely shielded from light to establish the black condition. The following processes are executed under the black condition of the photoelectric conversion unit SNS. The accumulation is completed not upon reception of the interruption /TINTE, but upon a time-out of a timer which counts up in a short time such as about 1 ms.

First, the sub-routine of determining the fixed pattern noise correction value is activated at Step (1100). Then, at Step (1101) a minimum result parameter value is initialized. This minimum result parameter value is compared with a minimum fixed pattern noise value at a later process. Therefore, this value is initialized to a value at least larger than the maximum level of the fixed pattern noise obtainable from the photoelectric conversion unit SNS.

At Step (1102) the A/D conversion result loop starts. This loop is repeated same n times as the number of the distance measurement pixel trains of the AF sensor.

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increment of 1.

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conversion value of each pixel, and this subtraction
result value is stored in the fixed pattern noise
correction information and dark current correction
information database (912) made of a non-volatile
5 memory. The non-volatile memory may be an EEPROM, a
flash memory or the like. The subtraction result value
may be output in an external storage device and then
stored in a ROM to make the database (912).

At Step (1111) one loop is terminated. This loop
10 from Step (1108) to Step (1111) is repeated to the n-th
pixel train. After all the pixel trains are completely
processed, the flow advances to Step (1112) to
terminate the sub-routine of determining the fixed
pattern noise correction value.

15 Next, a method of determining a dark current
correction value will be described with reference to
the flow chart of Fig. 13.

In determining the dark current correction value,
the photoelectric conversion unit SNS is shielded from
20 light to place it in the dark condition and measure
only the dark current. Since no incidence light is
applied to the photoelectric conversion unit SNS, an
accumulation is not completed, and the A/D conversion
to be activated the accumulation completion
25 interruption process is impossible. Therefore, instead
of the interruption signal via the /TINTE line for
calling the accumulation completion interruption

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external storage device and then stored in a ROM to make the database (912), instead of writing directly into a memory.

Step (1207) is the last Step of the loop starting from Step (1202), and Step (1208) is the last Step of the loop starting from Step (1201). After the m-th pixel, the flow returns to Step (1202), and after the n-pixel train, the flow returns to Step (1202), to thereby repeat the loops. After the n-th pixel train is processed, the flow advances to Step (1209) to terminate the dark current correction value determining process.

In the embodiment described above, the photoelectric conversion unit SNS 30 corresponds to a photoelectric conversion unit, the area sensor 31 corresponds to an area sensor unit, and the control circuit PRS 32 corresponds to a noise correction means. Noise information corresponds to the fixed pattern noise correction value and dark current correction value, noise information dependent upon the accumulation time corresponds to the dark current correction value, and noise information independent from the accumulation time corresponds to the fixed pattern noise correction value.

In the embodiment described above, the fixed pattern noise correction value is determined through A/D conversion of each pixel output in a very short

accumulation time of about 1 ms under the dark condition of the photoelectric conversion unit SNS. The dark current correction value is determined through A/D conversion of each pixel output in a predetermined accumulation time. This A/D conversion value is subtracted by the fixed pattern noise correction value, and the subtraction result value is divided by the accumulation time. The invention is not limited only to the above embodiment, but the following processes may also be used.

The A/D conversion values at two different accumulation times are first obtained under the black condition of photoelectric conversion unit SNS. Since the two different accumulation times and corresponding dark currents are known, the dark current value in a short accumulation time of about 1 ms, i.e., the fixed pattern noise value, can be calculated through extrapolation of two different accumulation times. The dark current correction value can be calculated thereafter by the similar method to that described earlier. In this case, the noise correction value corresponds to two or more dark current correction values.

Also in the above embodiment, the dark current correction value and fixed pattern noise correction value are first stored in the memory. Without using the memory, the dark current correction values and

fixed pattern correction values of each field may be calculated in real time to process pixel data.

Also in the above embodiment, noises are eliminated for an AF signal of the photoelectric conversion unit using area AF. A MOS type image pickup device or the like may be used as the photoelectric conversion unit SNS 30 shown in Fig. 8 and the image pickup signal of a subject may be processed by the noise elimination method of this embodiment. Namely, the photoelectric conversion unit 30 using area AF may be other photoelectric conversion units capable of converting an optical signal into an electrical signal.

Also in the above embodiment, although a plurality of pixels are used, only a single pixel may be used to obtain a correct dark current value dependent upon the accumulation time and hence a correct noise elimination, because the dark current values at least two accumulation times are used.

As described so far, according to the embodiment, since noises of a pixel signal can be corrected, a highly precise signal can be obtained.

By eliminating noises by software of a microcomputer, noise correction can be made flexible.

Many widely different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited

1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335</
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